THE FORESTS OF THE FLATHEAD VALLEY, MONTANA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LXVII.

HARRY N. WHITFORD.

(WITH MAP AND TWENTY-THREE FIGURES)

[*Concluded from p. 218*]

THE undergrowth of the Douglas spruce-bull pine combination is decidedly heath- or prairie-like. In the more open places grass is predominant, and associated with the grasses are *Balsamorrhiza sagittata*, *Monarda scabra*, *Lupinus ornatus*, and *Clarkia pulchella*. The most common bushes are *Prunus demissa*, *Amelanchier alnifolia*, *Opulaster pauciflorus*, and *Symphoricarpos* sp. In places where the rock is near the surface a heath-like appearance is given to the undergrowth by the presence of *Cladonia* sp., *Arctostaphylos Uva-ursi*, *Campanula rotundifolia*, *Selaginella densa*, *Lepargyraea argentea*, and *Pteridium aquilinum;* other forms noted were *Galium boreale*, *Achillea millefolium*, *Holodiscus ariaefolia*, and *Populus tremuloides;* and along the pebbly shores of the lake Crataegus is very characteristic.

On the southern slope of Swan Hill the vegetation conditions found on the exposed slopes of Mission Mountains are approximated, though this area is slightly more mesophytic; and the same may be said for the east side of Swan Lake. Here the shores end abruptly in a range of hills on whose west slope Douglas spruce and bull pine are characteristic, though here and there are scattered groups of western larch. Another meso-xerophytic area on the east side of Big Fork River, not far from the foot of the lake (*map*), has already been mentioned.

The country lying to the south and southwest of Flathead Lake is semi-arid (*fig. 5*), but in favorable situations there is some woody vegetation. A fringe of trees around the borders of the lake contains principally Rocky Mountain juniper, hawthorn, and bull pine; and the same condition is found along Pend d'Oreille River where

a low terrace has been formed. Dry ravines extending back from this lake also have a woody vegetation. The difficulties which trees meet in getting a start in a prairie region should be recognized. A very large majority of the seeds never germinate, and many that do germinate dry out before they have made a good start; and the sod also in many instances prevents the seeds from reaching the soil. The head of a ravine works back during freshets, undermines the prairie sod, and thus disturbs the vegetative equilibrium that had been established, offering a place more or less free from competition. If seeds fall on one of these bare places and do not dry out before the next rain which disturbs more of the soil, they may be buried by the moving soil; the seeds thus having the advantage of being planted and supplied with moisture at the same time. If the conditions remain stable long enough for the plant thus started to establish itself, it may hold its own even though there is considerable movement of the soil in the erosive process. Of course only a few plants out of the number thus established can exist long in the severe conditions of drouth that prevail in these regions.

The large moraine at the foot of the lake is almost destitute of trees (*fig. 5*), but isolated trees of Douglas spruce and bull pine were observed on its northern slope, and around them were a large number of seedlings, nearly all of which, in spite of their needle-like leaves, were nipped off by the cattle. It is very possible that if it were not for the cattle more of the trees would reach maturity, though it is doubtful if the increase would be very appreciable. However, if a slope was slightly more protected from the drying winds and the cattle did not interfere, open stands of both Douglas spruce and bull pine might exist. The hillside near the region shown in *fig. 6* illustrates the point; it slopes to the north, and the part of it under discussion is too high up the cañon of the Pend d'Oreille River to be influenced by proximity to the river, though probably trees near the river are the source of supply for the seeds that stocked the hillsides higher up. The bank is too steep for cattle to maintain a foothold easily, and except along paths young trees are not eaten by them.

As one approaches the forest formation to the north and east from the south end of Flathead Lake, trees become more prevalent, a number of hilly islands (*fig. 5*) in the lake showing an interesting

series of gradations. First there are hills with bull pine and a few Douglas spruce on the north and east slopes and few or none on the exposed slopes; then there are hills where a considerable number of bull pines find favorable conditions for development on the exposed sides of the hill (*fig. 18*), and with these there is some Douglas spruce. On the protected slopes the Douglas spruce becomes more abundant and may even destroy new growths of bull pine by their shade. Another set of hills nearer the forest formations show the south slopes fairly well covered with bull pine and Douglas spruce, while the bull pine has become less abundant on the protected slopes where the western larch element has been introduced. Thus there are all gradations from hills with few or no trees to those that have mesophytic elements on the north slopes. Of course there are many variations; for instance, hills a little to the north of west of the town of Big Fork have their southern slopes almost destitute of trees, while the protected slopes have a stand of Douglas spruce, western larch, and some bull pines. The series may be carried still further. It has been shown that the west slope of Mission Mountains has a forest of Douglas spruce and bull pine, while on the protected slope western larch is the most prevalent, and with it trees like lowland fir, silver pine, and giant arborvitae, which require still more moisture, are found. If the rainfall be sufficient, a mesophytic forest may be found on the exposed as well as on the protected slopes.

It may be well to analyze the conditions that make the so-called protected slopes more desirable for trees. Of course the great factor that prevents tree growth is the lack of moisture. If an annual rainfall of 400^{mm} falls upon a hill similar to those just described, and in gentle showers so that there will be little or no run-off, the water that leaves the soil directly must do so by evaporation, the remainder soaking in and becoming available for absorption. It is obvious that the slopes receiving the strongest insolation and exposed to drying winds will lose the most water by evaporation, and these are the south and west slopes; hence the north and east slopes will have more moisture in the soil. Again, the plants growing on these protected slopes do not receive so much heat and are not exposed to the drying winds, hence do not lose so much water by transpiration; they not only get more moisture but do not need so much to supply

the transpiration streams, therefore trees that require better moisture conditions can exist in these situations.

The sylvicultural habits of Douglas spruce and bull pine remain to be summarized. Douglas spruce has the widest life range of any of the species found in Flathead valley, being found at higher altitudes than any other of the lowland species, with the exception of

FIG. 18.—View of a portion of an island near the south end of Flathead Lake; a park-like growth of bull pine and Douglas spruce is present.

Engelmann spruce. It is found accompanying western larch all through the mesophytic forests of Swan valley, and forms even a greater percentage of the trees in the meso-xerophytic regions, and advances into the prairie sometimes as far as bull pine. However, this power of adaptation is not without an effect upon its form, for in high altitudes and on the border of the prairie region it is dwarfed and sometimes fasciated. In mesophytic conditions it reaches the dimensions of the trees with which it is associated, and even these

trees, though larger than most of the conifers of the eastern states, are small compared with the vigorous trees found in the hemlock-arborvitae-Douglas spruce forests west of the Cascade Mountains. It is in this region of greater rainfall and warmer winter months that Douglas spruce makes its best growth. With its great power of adapting itself to adverse conditions, it has spread through all the Rocky Mountain region as far south as Mexico. While Douglas spruce can adapt itself to varying conditions of moisture, it is very intolerant of shade, in this respect being like western larch, and even requiring slightly more open places in the forest to gain a foothold. Thus the tree will be reproduced only in open places in the forest.

The distribution of bull pine in Flathead valley is more limited than that of either Douglas spruce or western larch. It occurs in open park-like growths on the borders of the prairie formation, with patches of the prairie between (*fig. 18*). In the forest formations in the vicinity of Nigger Prairie there is a close stand of this species (*fig. 14*). Indeed so thick are the trees in certain situations that there is not sufficient light under them for the reproduction of either Douglas spruce or western larch, though young trees of Engelmann spruce and lowland fir can endure the shade. Isolated groups of bull pine are scattered through Swan valley, usually along streams where abundant light can reach them, and in pebbly soils, where other trees have difficulty in maintaining a stand, bull pine is found. Wherever a single tree is found surrounded by other trees it usually overtops them, showing that it probably started before they were present, for it is exceedingly intolerant of shade; it must have open places in which to pass its young stages, and this perhaps accounts for its scarcity in the mesophytic area in deep rich soils. Where found in Swan valley, it is a very healthy tree and very likely would do well in pure stands there if given a chance. In other words, bull pine does not grow in the dry soils on the border of the prairie because it prefers the moisture conditions found there, for it does better in the soils where there is more moisture; it is almost entirely forced out of the latter soils in the struggle for existence with the more successful trees. It undoubtedly demands a greater amount of heat than the other species, with the possible exception of lowland fir, for its altitudinal range is more limited. The highest point at which it was observed on the surrounding mountains was 1375^{m}.

A summary of the relation of the prairie to the forest in this region is as follows: (1) there is less moisture in the prairie soil than in the forest soil; (2) this is due primarily to the smaller amount of rainfall; (3) in the prairie formation forests may exist in certain topographic situations, as along streams and other bodies of water, and on protected hill-sides; (4) in the forest formation prairies exist where the character of the soil is such that it will not easily hold water; by the gradual addition of humus such soils may be changed sufficiently in their water-holding capacity to permit more mesophytic conditions and in some instances a climax western larch-Douglas spruce combination.

Objection may be made to the use of the term mesophyte for plants with xerophytic leaves. WARMING classifies all conifers as xerophytes because they grow in dry soils. In the eastern United States in contrast with the broad-leaved deciduous trees the conifers are undoubtedly xerophytes, comparatively speaking. That is, during the summer months the deciduous tree requires more moisture than the conifers, therefore the deciduous tree is excluded from the dry soils. In the northwestern United States the coniferous forests occupy the mesophytic soils almost to the entire exclusion of the deciduous element. As shown in the discussion on the climatic formations, this is due to a peculiar climate in which the summers are comparatively cool and dry, and the winters comparatively warm and excessively wet. In such a climate the deciduous tree is lacking, except in edaphic situations, on account of the cool dry summers, because with its broad transpiring surface it requires more moisture than it is able to get. The narrow-leaved sclerophyllous trees, on the other hand, while they do not necessarily thrive during the dry summer months, because of their reduced transpiring surface they are permitted to exist, while the broad-leaved deciduous trees cannot. During the winter the reverse is the case, for deciduous trees with their bare twigs are better able to endure severe conditions than are the conifers. On the other hand, if the climate is moist and warm, the conifer is able to do a considerable amount of photosynthetic work. Thus the deciduous tree requires more moisture during the summer months and is consequently more mesophytic at that season; on the other hand, the coniferous tree requires more moisture during the winter months and consequently is more mesophytic at that

time than the deciduous tree. Because of the equable distribution of moisture throughout the year in sufficient quantity in the eastern United States both can exist, although the deciduous element is able to occupy the mesophytic areas almost to exclusion of the coniferous element. In the northwestern United States the conifers, because the climate in which they grow is more suited to them, are able to occupy the mesophytic areas, and hence, so far as that climate is concerned, are mesophytes. Although they may have xerophytic leaves, the structure of the tree as a whole is more mesophytic during the non-growing season than is that of the deciduous tree. Taking the entire year into consideration, for the reasons given above I think that I am entirely justified in speaking of conifers as mesophytes.

III. The influence of fires on the present composition of the forests of Flathead valley.

In the discussion of the forest conditions up to this point little attention has been given to the influence of fires. There is scarcely a section of land in the area investigated that has not been more or less burned over. In some places mere surface fires have run through the woods, scorching the trunks of the trees sufficiently to scar them. In other situations the fires have burned vigorously through small areas killing many of the trees. Still other fires have destroyed completely large areas, leaving many acres with not a single tree. Such is the case on the west slope of the Mission Mountains (*figs. 4, 16, 17*). There are many small clearings made by settlers, who after proving up their claims have deserted the cabins erected upon them (*fig. 19*).

By marshaling the facts collected by a study of the conditions of reforestation in these fire clearings, nearly all stages in the establishment of new mature forests were determined. Studies in similar regions outside of the area plotted have proved very helpful in the interpretation of these conditions. Some important principles must be kept in mind in explaining what plants will first get a foothold in the open places made by fires. These are as follows:

1. The subterranean parts of some plants that are able to sprout from roots or underground stems may not be destroyed by fire. The sprouts of these species will give the burn a decided aspect in a short time.

2. Other things being equal, the plants whose seeds are in the burn first will gain the earliest foothold.

3. Those plants that have seeds there early after fires will be those that have seeds well adapted for distribution.

4. Of the plants that have their seeds equally well adapted for distribution, those with seed-bearing representatives standing nearest the burned area will have the advantage.

5. Again, other things being equal, of those species that have their seeds equally well adapted for distribution and have seed-bearers equally near the clearing, the species that produce seeds most abundantly will be apt to win out in the struggle.

6. The species that can resist fires the best are likely to have left standing in or near the area itself seed-bearing parent plants.

7. The conditions of the soil must be such that it will permit the germination of the seeds that fall upon it. If the soil is too moist, too dry, too poor, or too much shaded, no matter how many seeds fall upon it, none will germinate.

These well-known principles will aid in the determination of the causes of the many complex conditions of forest growth after fires. Before the actual conditions of the clearings are considered, however, the ecological habits of another tree, the lodgepole pine, must be known.

The lodgepole pine covers large areas in Swan valley, sometimes forming almost pure stands. It is able to exist and thrive in those moist areas where it has to compete only with the spruce and its associates. It is found mixed with all the other species in the mesophytic portion of the valley. Toward the borders of the meso-xerophytic areas it is not so prevalent, though signs of it were noted west of Echo Lake and in the mesophytic portions of the west slope of the Mission Range. It does not advance into the prairie formation, however, so far as the bull pine and the Douglas spruce. Its altitudinal range was not investigated. It is difficult to tell whether or not this tree would maintain a stand in the Flathead valley if it were not for the influence of fires. It is intolerant of shade, in which respect it may be ranked with western larch and Douglas spruce, reproducing in open places only. No young trees were noted in the shade, save an isolated poorly developed specimen now and then

in the slight shade of a mature stand of the same species. Probably it is a little less exacting in its light requirements than western larch and Douglas spruce.

The lodgepole pine is a prolific seeder, beginning to bear fruit early in life. Out of twenty trees varying in age from five to twenty years, many had cones. The youngest tree noted with cones was six years of age, one at this age having seven cones. On one tree nine years old fifty cones were counted. It was a common thing to find clumps of trees 3 to 4^{m} high fruiting abundantly. As will be shown below, this habit of fruiting early in life is of very great advantage to this species. Another thing of very great importance is the fact that the cones remain closed in some instances a number of years, thus preserving the seeds. The heat of a fire will open them and liberate the seeds, many of which will escape injury and germinate at once. The lodgepole pine, during its early stages at least, grows rapidly in height, and this gives it some advantage over its competitors. From the measurements of twenty-five specimens each of lodgepole pine, western larch, and Douglas spruce, the average rapidity of growth in height per year is shown to be as follows: lodgepole pine 52^{cm}, western larch 27^{cm}, Douglas spruce 20^{cm}. Although these averages are from rather meager data, they are sufficient to show that the lodgepole pine has by far the most rapid growth.

In contrast with western larch, Douglas spruce, and bull pine, lodgepole pine has poor fire-resisting qualities. Except in old trees the bark at the base is comparatively thin; the cambium layer is thus easily scorched and killed. In this way many whole forests of trees are destroyed by fires that are not intense enough to consume the trunks. It is not an uncommon thing to see acres of dead standing poles of this species that have thus been swept by fire. In showing how successful lodgepole pine has been in obtaining a foothold in the forests of Swan valley, the principles mentioned above must be kept in mind. The rôle that the plants other than conifers play in the reforestation stages will be treated in another connection. In order that the conditions may be understood more clearly, hypothetical cases will be assumed, and when these hypothetical cases are realized attention will be called to them. Suppose a limited area is burned in the midst of a forest in which western larch and Douglas

spruce are the dominating trees, and that these are mixed with lodgepole pine, silver pine, and lowland fir. Suppose that the trees surrounding this area all bear cones, and all have their seeds equally well adapted for wind distribution. Since not one of the conifers found in the region is able to sprout from the roots that would be protected from the fires, all would have to start from seed. Let us suppose

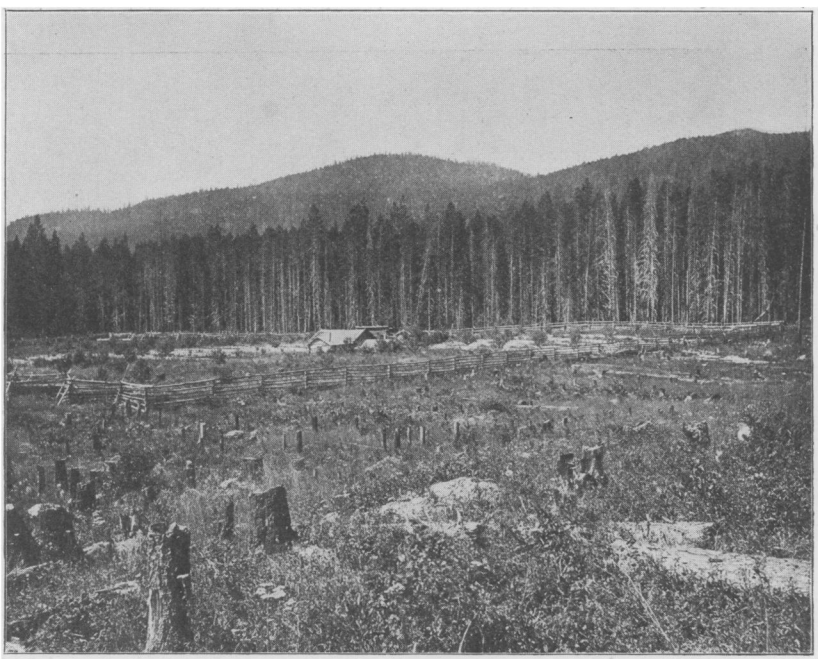

FIG. 19.—A clearing in a lodgepole pine forest in Swan valley; east slopes of Mission Mountains in the background; these slopes have a mesophytic forest of western larch and Douglas spruce.—Photograph by PRAEGER.

that the seeds of all fall in equally favorable places, and that the seedlings that spring up are numerically proportional to the parent trees in the undestroyed stand surrounding the burn. Each species in the forest adjoining the new growth will thus be represented in the burn in the same proportion as it is in the mature stand. If all the young trees grow with equal rapidity, and the natural thinning out is proportionately distributed among the species, the new stand will be just like the old. There are some small burns where this

condition is approximated; of course the proportions are not exactly the same in the old and new stands (*fig. 20*). Granted that any one of the species in the young forest grows more rapidly in its youth than the others, other things being equal it would gain an ascendancy over its neighbors, and in the forest approaching maturity it would have more representatives than in the old forest. As already shown, lodgepole pine bears exactly that relation to Douglas spruce and

FIG. 20.—Young growth of lodgepole pine and western larch in a clearing surrounded by older trees of the same species, both of which have seed-bearing trees; other plants are dwarf maple and a willow, both of which sprout from old stumps; fireweed is also a characteristic plant.—Photograph by PRAEGER.

western larch at least, and probably to the other species, though no measurements were taken for them. In the new forest thus established, lodgepole pine has made a gain on the other species. However, it reaches maturity sooner than the others, and in the old forest it is the first to drop out in the struggle for existence, so that while in the middle-aged forest it may have had some slight advantage, it loses this and often is entirely eliminated from the mature stand.

Many instances were noted, especially in the region outside the plot mapped, in which lodgepole pine was thus being driven out of forests where doubtless it was more prominent in the young stages of development.

Referring again to the original case, it will be seen to be highly improbable that the species in the stand around the hypothetical burn

FIG. 21.—Young growth of lodgepole pine and Engelmann spruce in a clearing of the same species.—Photograph by PRAEGER.

would produce seeds equally well. Some species might not have any seeds at all, and they would form no part in the new forest unless a few seeds are blown into the area from regions where there are seed-bearing trees. The lowland fir during the past two years has produced few if any seeds in Swan River valley. Any burn made in the valley then within two years could not be stocked with seeds of this species. If for instance Douglas spruce or western larch produce seeds more abundantly than any of the other trees, they are likely, other things being equal, to have more representatives in the

new forest than in the old. So if any other tree, lodgepole pine for example, has more seeds than the others, it will increase in numbers in the new stand that is formed. So far as its relation to restocking a burn is concerned, a tree that does not produce seeds might just as well not exist at all.

This leads naturally to another modification of the hypothetical case, in which the forests that surround the burn have only one or two species instead of a number. The result will be that these species are likely to be the only ones found in the burn. Such a condition is seen in *fig. 20*, where the forest that surrounds the clearing is composed mostly of western larch and lodgepole pine, and these species are the predominating ones in the new growth. *Fig. 21* shows a clearing surrounded principally by lodgepole pine and Engelmann spruce, which are almost the only trees present in the new stand. Again, *fig. 22* shows that bull pine, western larch, and Douglas spruce are present in an opening in a mature forest of these species. Another explanation for this, however, is that the area is situated on the border of the meso-xerophytic region where probably no other species could exist, even if their seeds were present.

This leads to still another modification of the hypothetical case. Assuming that the seeds of all the species are present, it is highly improbable that they would find equally favorable places for germination. The case just cited (*fig. 22*) is an instance of where all except western larch, Douglas spruce, and bull pine are ruled out. If the fire burnt out an Engelmann spruce stand surrounded by a less swampy region in which Engelmann spruce, lowland fir, silver pine, Douglas spruce, western larch, and lodgepole pine were present, only Engelmann spruce and lodgepole pine would be able to restock it, for these are the only species that could grow in the swampy situations. An instance of such restocking was noted near the head of the bay-like area of meso-hydrophytic forest southwest of Ross Lake.

Still other conditions of reforestation remain to be explained. Taking the hypothetical area that has been restocked with the seedlings of all the trees in the surrounding forest, and assuming that the young growth is approximately fifteen years of age, the only species of this young growth that would have fruit is lodgepole pine. The cones on this pine would be more or less abundant, and on all

the others the cones would be absent. If a fire should sweep through this young growth, destroy it, and at the same time consume some of the original forest around it, thus extending the limits of the original burn, what would be the result? The extent of the burned area being greater, the seeds of the trees bordering it could not so readily be carried to the center of the burn. But this portion of the clearing would be restocked with the seeds of young lodgepole pines that were destroyed by fire, but whose seeds would be more or less protected from the fire by the cones. Some of the cones would be cracked open by the heat of the fire and the seeds would be liberated. The result would be that the next forest would contain more representatives of lodgepole pine than the former forest, and that they would be more numerous in the center. Indeed this center might contain a pure growth of lodgepole pines. Another such fire in the course of fifteen or twenty years or less would enlarge this area at the expense of the other species. Thus almost if not quite pure forests of lodgepole pines of considerable extent would be established. It is very probable that the mature lodgepole pine forest found in Swan River valley was established in this way (*fig. 23*). The evidence for this is as follows:

1. In no case was a stand of this species found in which there were not noted dead and charred trunks of western larch and Douglas spruce, mostly the former; these because of the thick bark would be the last to yield to the fire. In some instances mature live trees of western larch were observed towering above the younger lodgepole pine forest. In these cases there were isolated specimens of young western larch of about equal age growing with lodgepole pines (*fig. 12*).

2. In nearly all cases these forests grade imperceptibly into more mature forests in which the lodgepole pine element is entirely or nearly wanting. The mature forests of western larch, Douglas spruce, silver pine, lowland fir, and lodgepole pine are in many instances growing in soil that is similar in moisture content. Thus it cannot be said that the difference in the two stands is due to the character of soil conditions.

3. In the meso-hydrophytic situations there is often a gradation from a spruce forest to a mixture of Engelmann spruce and lodgepole pine, the latter stand being much younger than the former.

4. In stands that contain little or no signs of fires, the lodgepole pine element is absent or nearly so.

5. Nearly all stages in the development toward this condition were noted. Thus, *fig. 20* shows a comparatively recent clearing in a young lodgepole pine forest, which is in turn surrounded by a mature forest of western larch and Douglas spruce in which the lodgepole pine element is inconspicuous. *Fig. 12* shows an almost pure growth of this young forest with mature trees of western larch in it. In another place there is a more mature growth in which only charred trunks of larch tell the tale.

For the reasons given above, it is believed that the explanation for the lodgepole pine in the area plotted is the correct one. As before stated, observations were not limited to this immediate region, and many instances might be cited where burned areas similar to those described have become reforested with lodgepole pine. It will not be out of place to repeat that the advantage which it has over the other species in the region is due to its capacity to produce seeds early in life, and its habit of retaining the seeds in its cones for a number of years, thus preserving them for a greater or less length of time. In forests partially destroyed by fire the trees of western larch and Douglas spruce, because of the capacity of their trunks to resist rather severe burnings, will restock the burned areas. Fires of this nature, repeated sufficiently often to prevent any young lodgepoles from becoming old enough to produce cones, will militate against the latter, while Douglas spruce and western larch will have cone-bearing trees on the ground so long as the fires are not too intense. As soon as these are destroyed, then the seed supply is cut off and restocking from that source at least will discontinue.

It will be seen readily that if the fires that have made the lodgepole pine condition possible are repeated every five years, for instance, the young growth forests of that tree will not be permitted to follow each other in procession, for the five-year interval between fires will be too short a time to permit lodgepole pine to produce seeds. Then of course all forest growth will be completely destroyed and the area will not become clothed with trees until restocked with seeds from the neighboring undestroyed forests. The further these are away, the longer it will take for seeds to reach the devastated area. However,

if the interval between the fires is sufficiently long to give lodgepole pine time to produce seeds, after each fire a forest of lodgepole pines will spring up to replace the old. Such fires enable lodgepole pine to perpetuate itself so long as the soil is able to furnish the requisite amount of nourishment, but a checking of fires will in time bring about the normal conditions. This has been done about as follows:

The fires being absent, the lodgepole pine stand is permitted to reach maturity. As it does so, seeds of forest trees in the neighboring undestroyed or partially destroyed stands have had time to spread into the lodgepole pine forests. Seedlings of those trees that can tolerate the shade will get a start at once, if the other conditions are favorable. Thus in many instances silver pine, lowland fir, and Engelmann spruce were noted growing under lodgepole pine stands in Swan valley. Also in the Terry Lake region seedlings of giant arborvitae and western hemlock were observed in similar situations, although, because of the restricted area to which

FIG. 22.—Young growth of western larch, Douglas spruce, and bull pine in a clearing of the same species.—Photograph by PRAEGER.

these two species are confined, their occurrence under lodgepole pine stands is not common. As soon as openings are made in the forest of mature lodgepole pines, due to causes other than fires, this undergrowth may spring at once into prominence and may come to occupy a place in the mature forests. At the same time the openings have made it possible for the existence of seedlings of such trees as western larch and Douglas spruce which demand light for germination. Of course lodgepole pine seedlings can germinate here also, and in the first generation or two they will still predominate; but each new generation will have fewer specimens of the latter species, for since it is not a long-lived tree, a canopy of the mature forest of the other species will in the long run crowd it out by density of shade, or reduce its occurrence to isolated trees here and there in the forests. In this way the forests will revert to the normal conditions. The time it will take to do this depends upon the nature of the conditions that the last fire left. If the lodgepole pine conditions had been established for a wide area, the time would be long, perhaps covering many generations of growth. If on the other hand the fire only partially destroyed the original forest, one or a few generations would suffice to permit the re-establishment of a forest similar to the original. Between these two extremes are all stages, some of which have been described. Indeed the present forest formations are a complex expression of the influence of fires upon them.

The general aspect of a lodgepole pine forest approaching maturity is somewhat different from that of other stands. It has already been shown that the growth in height is rapid. In dense stands of young growth the poles are long and spindling, hence the name lodgepole pine. The small diameter of the bole of the tree is very characteristic. A forest in which the average age of the trees is about one hundred years is seen in *fig. 23*. In this forest, where the trees are over a hundred years old, the average diameter is probably 20^{cm}, many trees being only 15^{cm} in diameter.

Compared with the other forests growing in like situations, the canopy that a lodgepole forest forms is not very heavy. This permits more light to reach the forest floor, hence there is a greater development of undergrowth. It has already been shown that seedlings of silver pine, Engelmann spruce, and lowland fir can endure

the shade of these forests, and that except in open places Douglas spruce, western larch, bull pine, and lodgepole pine are ruled out altogether. The birch is found scattered throughout the limits of the forest. Indeed, as will be shown, it is often a conspicuous tree

FIG. 23.—Mature lodgepole pine forest in Swan valley, showing a dense stand in which the trunks are 15 to 20cm in diameter; the undergrowth consists of *Acer glabrum*, Pyrola, Pteridium, Linnaea, etc.—Photograph by MCCALLUM.

in the burns, and grows up with lodgepole pines, though as the forest matures it drops out early. The undergrowth consists of *Acer glabrum*, *Lepargyraea canadensis*, *Symphoricarpos* sp., *Rosa* sp., *Lycopodium* sp., *Pyrola secunda*, *Pteridium aquilinum*, *Linnaea borealis*, *Chimaphila umbellata*, *Clintonia borealis*, and *Aralia nudi-*

caulis. Scattered specimens of juniper are found in places. In other respects the forest is like the other stands in the mesophytic regions.

In what has been said concerning fires, no mention has been made of species other than conifers. They may often play an important rôle in the first stages in the natural process of reforestation, but their importance diminishes as the life history becomes complete. One of the first plants to give a decided aspect to the forest after fires is the fireweed (*Chamaenerion angustifolium*). The birch and aspen, by virtue of their light seeds, gain an early place in the burns. Indeed sometimes their stands become quite dense and they check the advent of coniferous species. Many species that were on the forest floor of the mature stand may have survived the fires and spring up even more vigorously than before, because the shade has been removed. Especially is this true of those forms that can send shoots from their roots or from underground stems. In the burn on the east slope of the Mission Range south of Big Fork, there are shrubby growths of *Salix* spp., *Ceanothus sanguineus*, *Opulaster pauciflorus*, *Acer glabrum*, and *Holodiscus ariaefolia*, many of which probably were present as underbrush in the stand that existed previous to the burn. These shrubs will retard the reforestation of the area in some instances to a marked degree. If the forest that is destroyed be on the border of the prairie, plants from that association will form an important element in the growth that follows. This is of course detrimental to forest growth. Indeed if the fires be repeated often enough, the forest plants will gradually diminish in quantity, and the prairie element will become more and more prominent, until finally a prairie will come to replace a forest. If the fires be checked, however, for any length of time, the forest will gradually reconquer the territory thus lost. It is probable that some of the prairie region in Flathead valley has been won from the forest in this manner. It must be remembered that in the area bordering on the prairie, in Flathead valley at least, lodgepole pine is not successful and is thus ruled out from playing any important rôle in these places after fires.

In the discussion of the causes for the Nigger Prairie region, mention was made of the importance of the accumulation of humus in rendering the sandy soil more capable of holding moisture. It

can be seen that fires will tend to reduce the humus content of the soil. This is of extreme importance, for that which would otherwise add to the richness of the soil and increase its water-holding capacity is destroyed. Especially is it of importance in those regions that border on the prairie. There is evidence of many such surface fires in the open woods around Nigger Prairie, and it is very probable that these fires have played an important rôle in keeping the prairie vegetation from being encroached upon by the forests that surround it. Even in the mesophytic conditions, fires influence the capacity of the soil to reforest itself quickly, by partially or totally destroying the humus. However, with the reclothing of the burned area, the floor of the new forest will gradually resume its normal condition.

From the above it will be seen that forest fires play an important part in determining the composition of the forest. That forest fires prevailed in this region before the advent of civilized man is a logical inference. In the lodgepole pine forest in the Swan River there are unmistakable signs of fires before the present forest, which is now about one hundred years old, was started. How these fires started can only be conjectured, and it is not within the province of this paper to discuss their origin. It is also very evident that the fires are more numerous since the settling of the country by civilized man than before.

SUMMARY.

1. Fires play an important part in determining the present composition of the forest.

2. The lodgepole pine is the "fire tree" of the region.

3. It is favored after fires principally because it has the capacity to produce seeds early in its life.

4. Many complex conditions of growth are introduced after fire. The species that have seed-bearing trees near the burn will generally be represented in the new forest.

5. Repeated burnings at intervals of ten to thirty years will establish a lodgepole pine forest where formerly there existed a normal mesophytic forest.

6. Repeated burnings at intervals of five years or less will destroy all forest growth.

7. After the lodgepole forest is once established and the fires are checked, it will slowly be replaced by the species that exist in the normal forests.

8. The lodgepole pine is not successful in the bull pine belt.

I wish to thank Dr. H. C. COWLES for many valuable suggestions made in the preparation of this paper; also Professor M. T. ELROD, through whose kindness I was permitted to make the Montana Biological Station headquarters while collecting data; also Professor ELROD, W. E. PRAEGER, and W. B. MCCALLUM for the photographs from which the illustrations were made. The taxonomic nomenclature used in this paper is that found in RYDBERG'S *Catalogue of the flora of Montana and the Yellowstone National Park*, and SUDWORTH'S *Check list of the forest trees of the United States*.

GOVERNMENT LABORATORIES,
Manila, P. I.